TOF rate studies and … else

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(R.Bertoni, M. Bonesini, A. de Bari, M. Rossella, R. Nardo')

Outline

1. HV crate refurbishing
2. A backup solution for TOF in case **B** fields in the MICE Hall is out of control
3. The rate effect problem

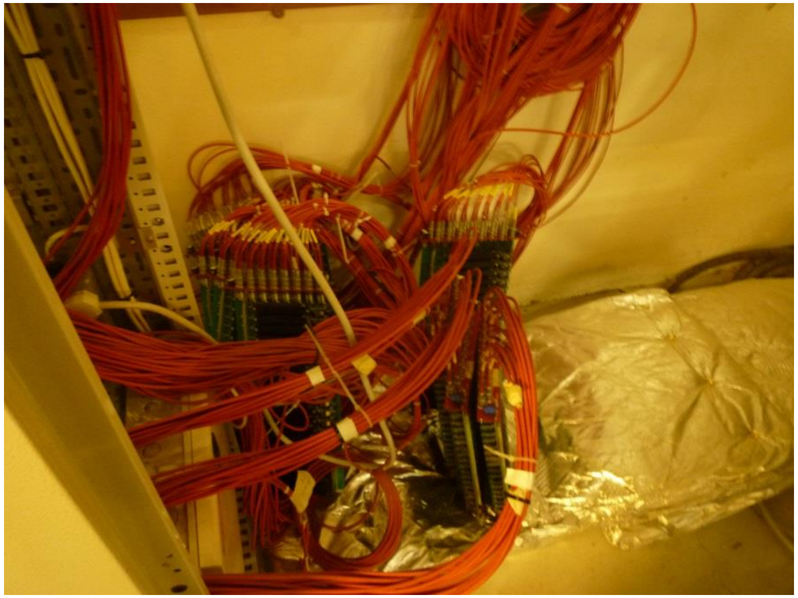
- Conclusions

1. SY527 HV crate refurbishing

- TOF and KL share a common HV system based on a SY527 crate

- Some minor problems were pointed out by the MOM
- An intervention was done at the beginning of this week to clean up the crate and eventually change the air fans (R. Bertoni, M. Capponi, A. Iaciofano) → now things are OK

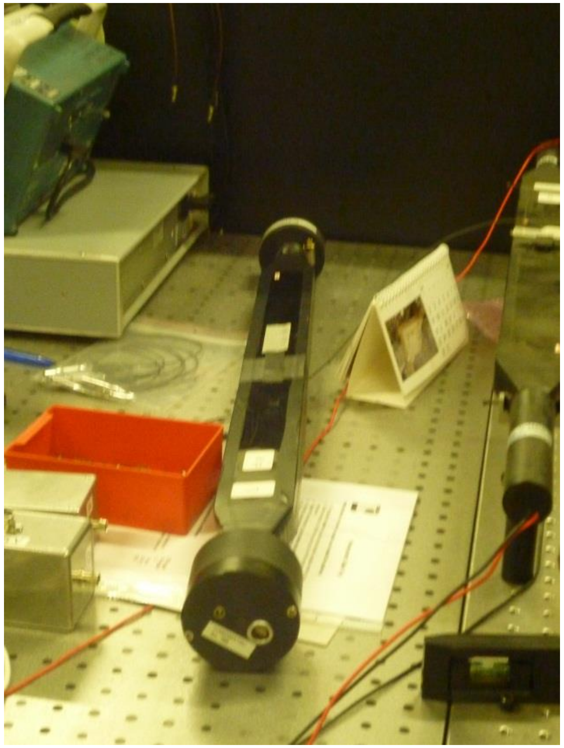
SY527 HV crate refurbishing



dusty inside

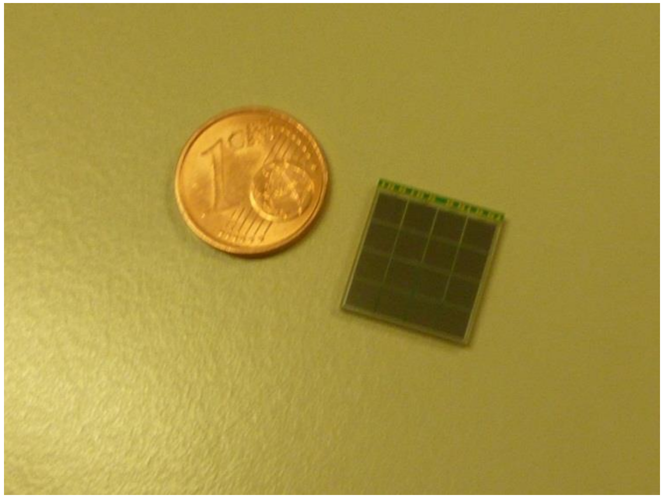
2. A backup solution for TOFes

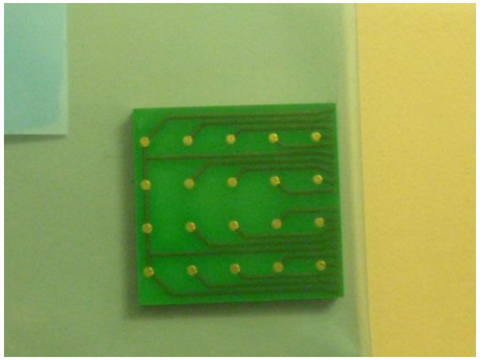
- We were serioiusly concerned with the level of stray magnetic fields in the MICE Hall: bigger than foreseen by GG/JC/… ??
- Study a straight backup solution for present TOF stations, in case of problems : with SiPMT arrays readout (not sensitive to B fields up to few Tesla) replacing conventional PMTs (R4998)
- Idea: just use 2 SiPMT arrays instead of 2 PMTs with the same TOF mechanics layout, lightguides …



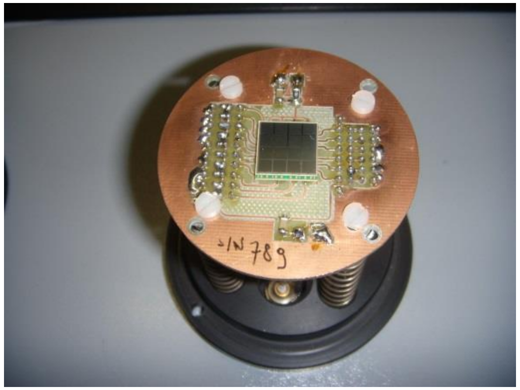
SiPMT arrays used

- Use 4x4 arrays of SiPMT 3x3 mm^2 (SenSL, Hamamatsu) or 4x4 mm^2 (FBK/IRST) to study if it is possible to replace 1" PMTS
- Preliminary studies with our test laser setup and cosmics
- Effort MIB+PV (M.Bonesini, R. Bertoni, G. Stringhini, A. deBari, M. Prata, M. Rossella, R.Nardo')

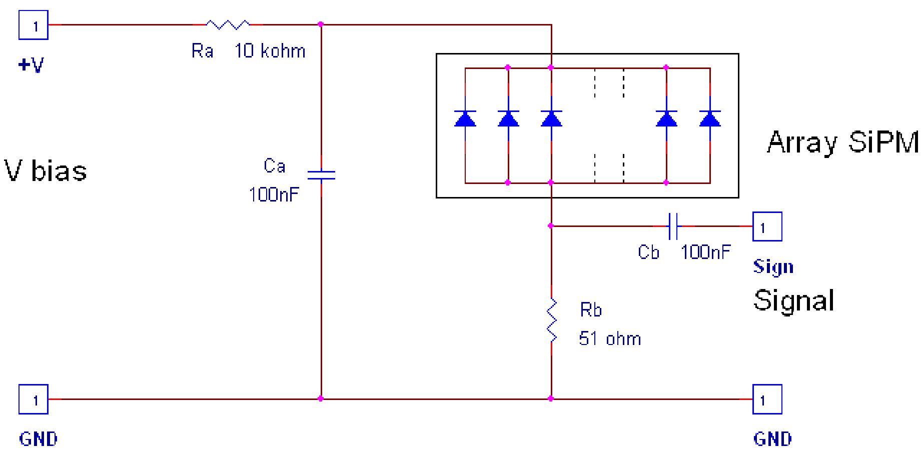




Readout chain for SiPMT arrays

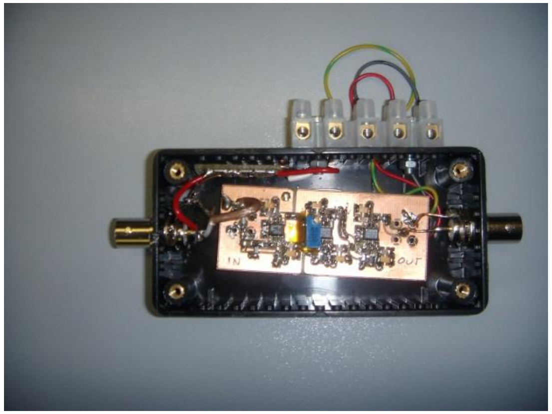


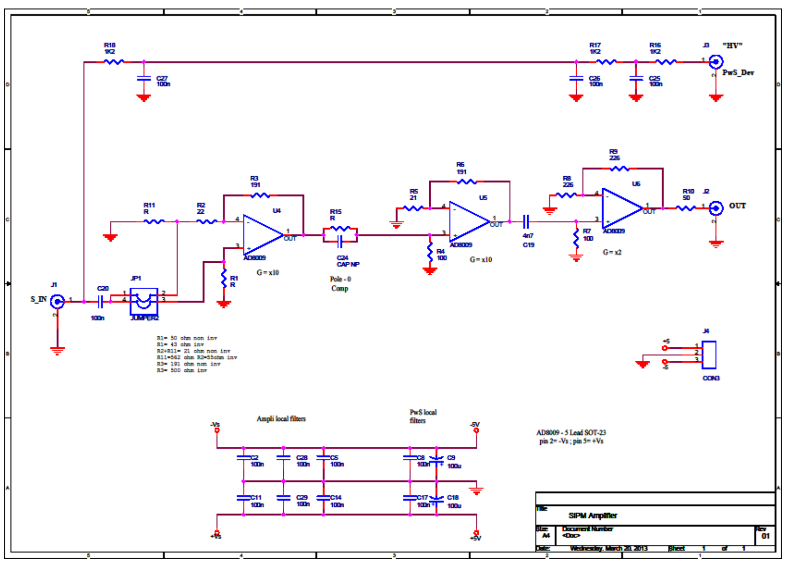
- SiPMT array custom mount
- 16 macrocells signals are summed up in the basette and then amplified



Schematic of one ``basette”

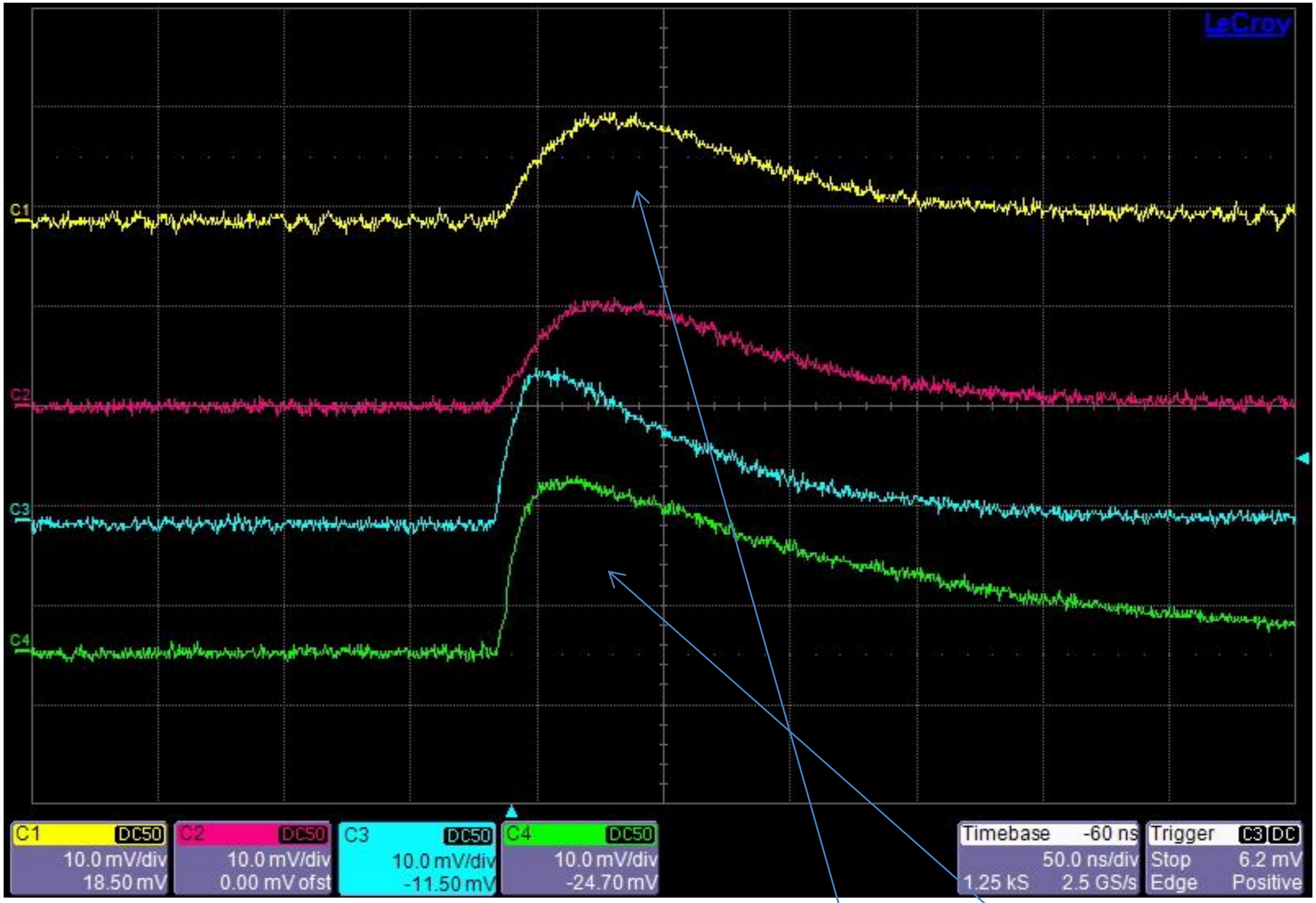
Custom amplifier





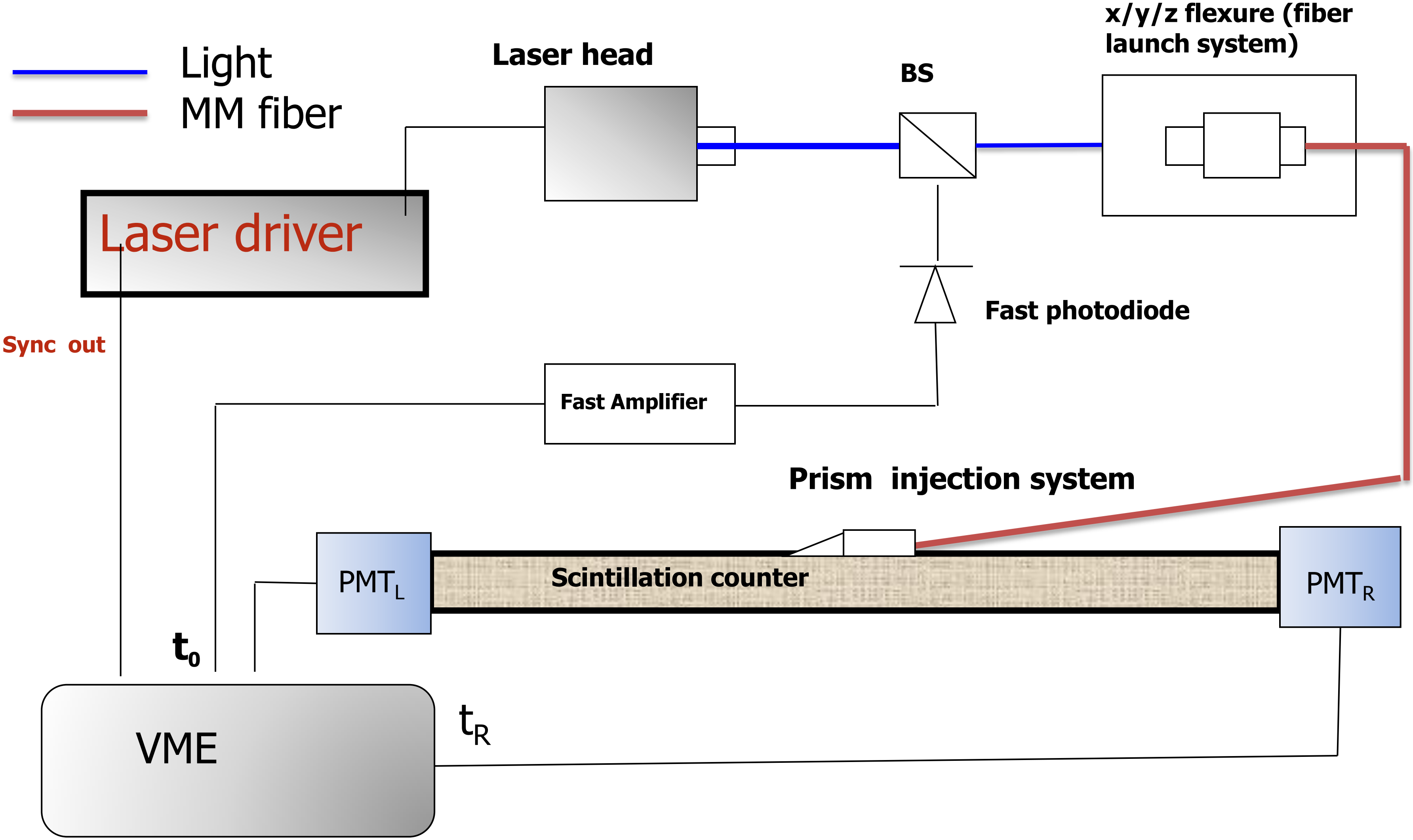
Amplifier:

- Custom made (INFN Pv)
- 1 or 2 channels
- Gain up to 100X (30X with pole zero suppression)
- Input dynamic range: 0-70 mV
- Bandwith : 600 MHz

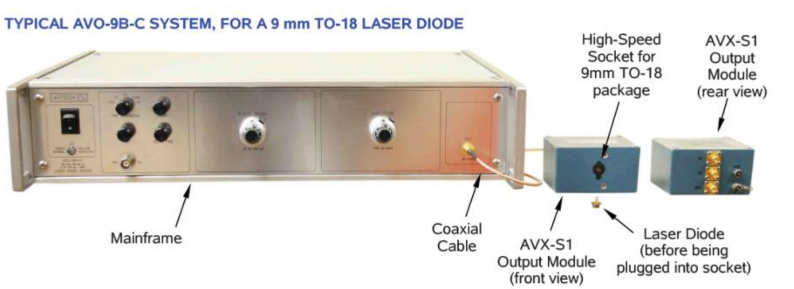


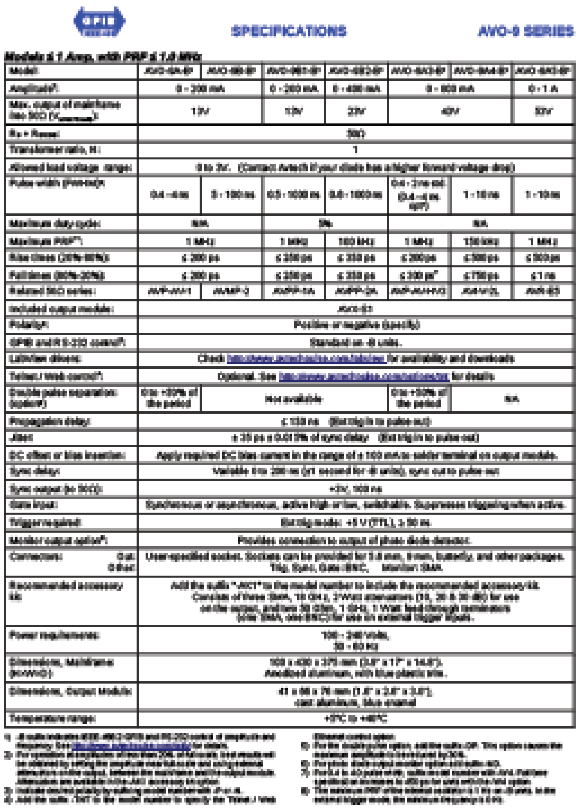
2 crossed bars equipped with SenSL or Hammamatsu SiPMT arrays, trigger on cosmics

Experimental lab setup



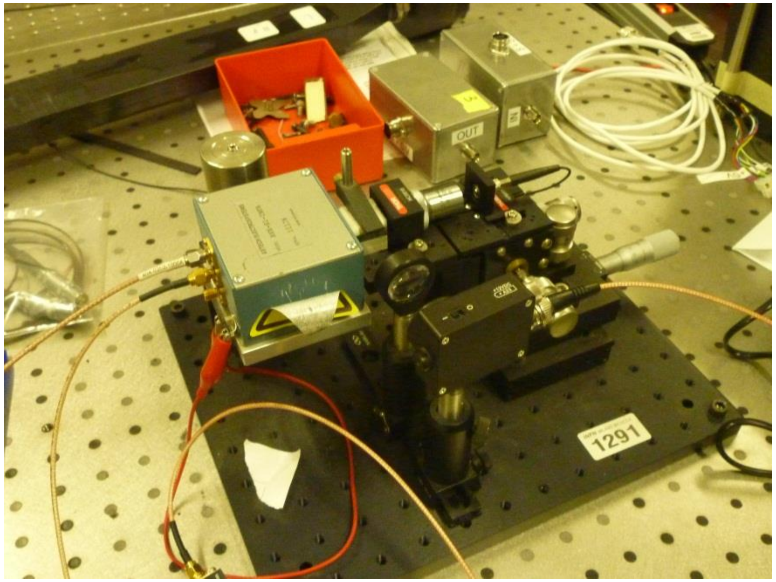
Test setup: home-made laser system





1. **Fast Avtech AVO pulser + Nichia violet laser diode (λ ~408 nm)**
2. **Laser pulses width selectable between 120 ps and 3 ns length, with a ~200 ps risetime (simulate scintillator response)**
3. **Laser pulse height selectable to give scintillator response between a fraction of MIP and 10-50 MIPS**
4. **Laser repetition rate selectable between ~100 Hz and 1 MHz**
5. **The laser beam is splitted by a 50% beamsplitter to give a reference t0 on a fast photodiode (Thorlabs DET10A risetime ~1 ns) amplified via a CAEN A1423 wideband inverting fast amplifier (up to 51 dB, ~1.5 GHz bandwidth)**

Some details



Acquisition system:
- **VME based (CAEN V2718 interface)**
- **VME CAEN TDC V1290A (25 ps res)**
- **VME CAEN QADC V792**
- **VME CAEN V895 L.E. discriminator (typ discr values -50 -100 mV)**
- **home-written acquisition software**

Laser injection system:
- **Newport 20X microscope objective**
- **x/y/z Thorlabs micrometric flexure system**

Tuning of laser setup

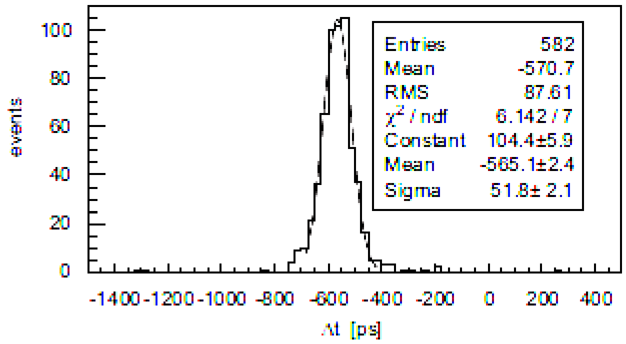


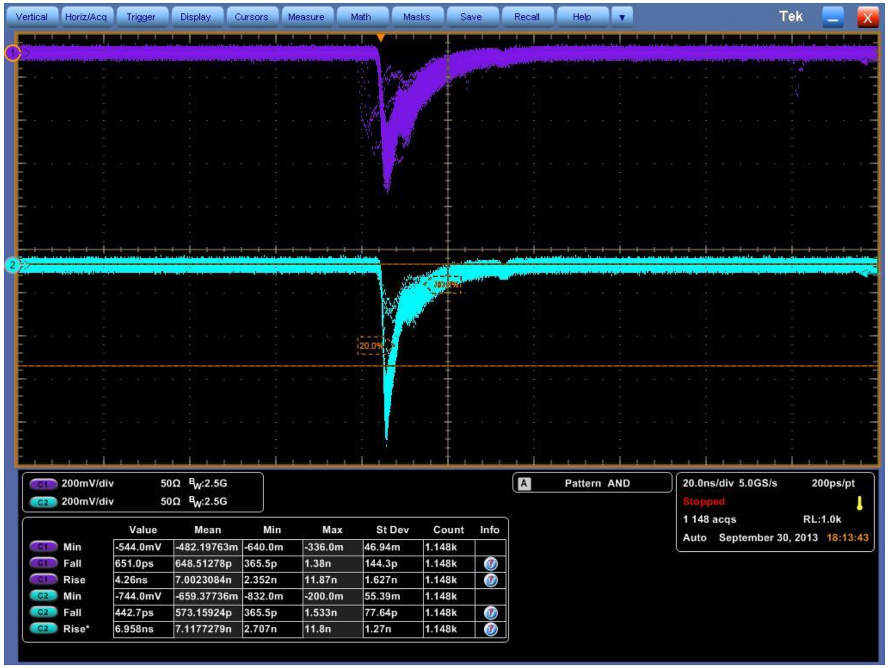
Fig. 12. $(t_L - t_R)/2$ distribution from a BC404 bar specimen and beam impact point at $x = 20$ cm (counter center).

Table 2
Intrinsic resolution of counters made of scintillation bars of 4 or 6 cm width and with lightguides made of different materials and/or of different shape (Winston cone or fishtail).

Counter type	σ_t (ps)
UPS95F 4 cm bar Winston Cone	56 ± 2
UPS95F 4 cm bar REPSOL UVT lightguide	50 ± 8
BC404 6 cm bar REPSOL UVT lightguide	46 ± 5
BC420 6 cm bar REPSOL UVT lightguide	45 ± 1
BC408 6 cm bar PERSPEX UVA lightguide	60 ± 2

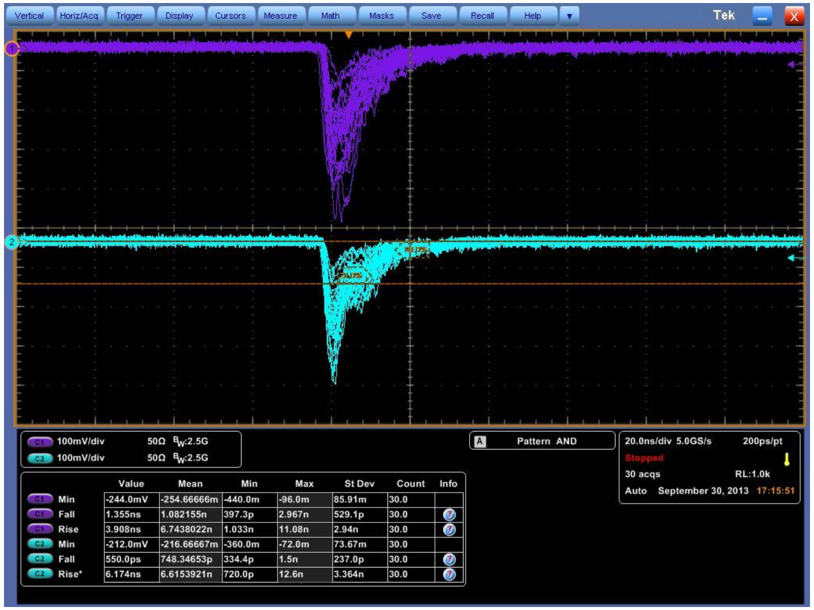
From R. Bertoni et al., NIM A615 (2010) 14

- **Tune laser settings to reproduce testbeam results (σ_t)with a single counter equipped with R4998 PMTs and MIP response**
- **Study single counter response substituting PMTS readout with SiPMT arrays readout**
- **Advantage as respect to cosmics is the possibility to collect a high statistics in a short time, with different exp conditions (amplifier tuning, …)**



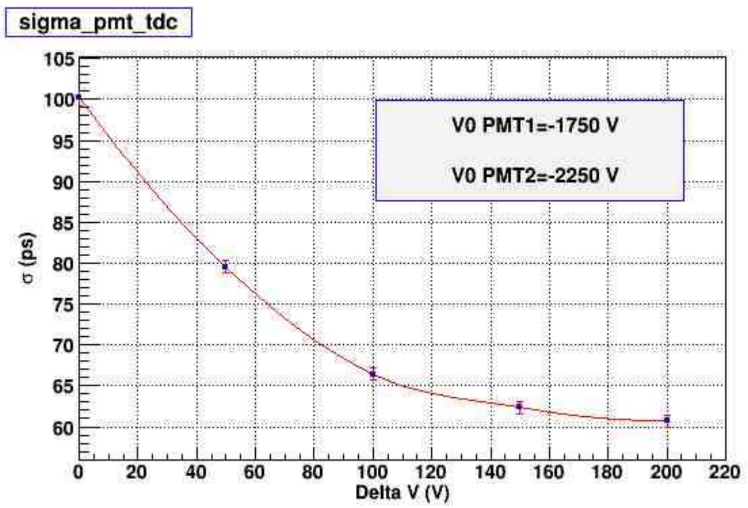
BC 404 scintillation counter (60 cm long, 6 cm wide) equipped with Hamamatsu R4998 PMTs (as in MICE expt)

PMT signals with laser

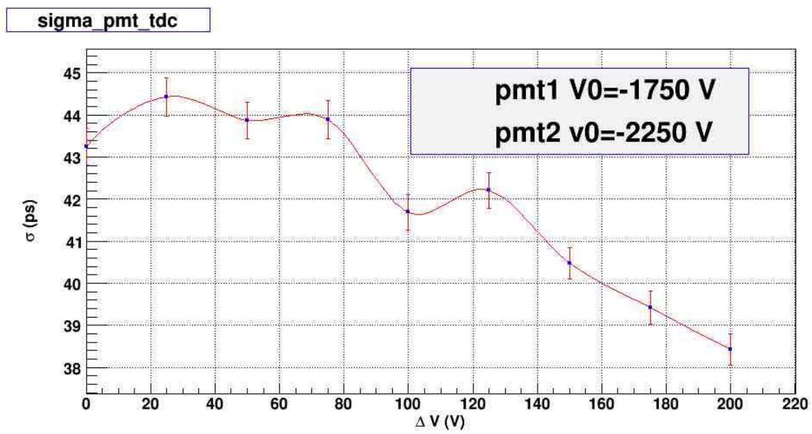


PMT signals with cosmics

Results with conventional PMTs (as benchmark)



Very low laser light intensity (1 MIP or less)

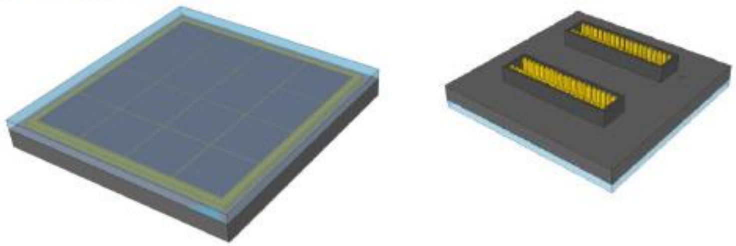


Standard laser light intensity (2-3 MIP)

$V_{op} = V_0 + \Delta V$

Results with FBK/IRST arrays

ASD-SiPM3S-P-4X4A



4×4 SiPM Array

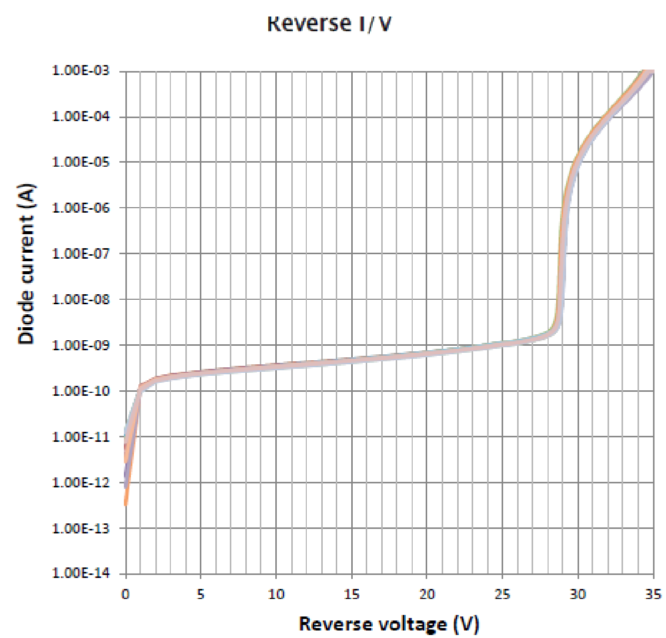
3 mm pixel pitch

2.95x2.95 mm^2 SiPMs
50 μm gap between SiPMs

Material: FR4 +
transparent epoxy layer

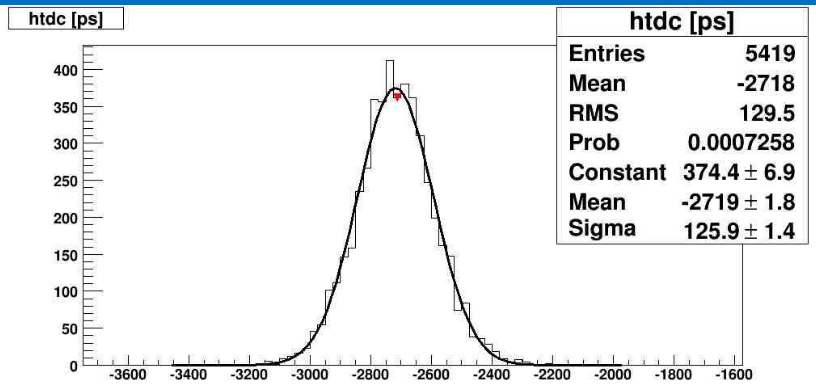
AVX 5602-040 series
plug connectors

Receptacles included
(AVX 5602-040 series)

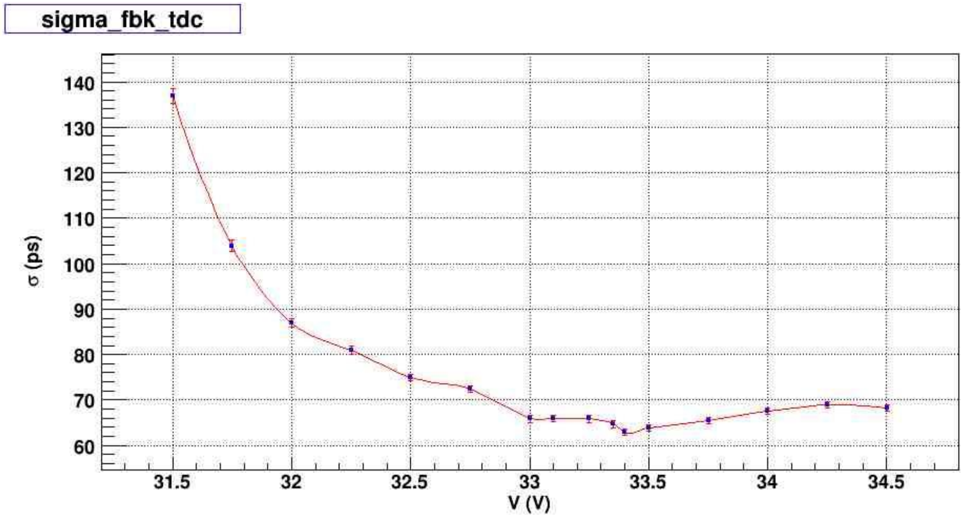


SiPMT I-V characteristics
(manufacture specs)

Results with FBK/IRST SiPMT arrays



Typical difference ΔTDC (converted in ps) : $\sigma_t = \sigma_{\Delta TDC}/2$

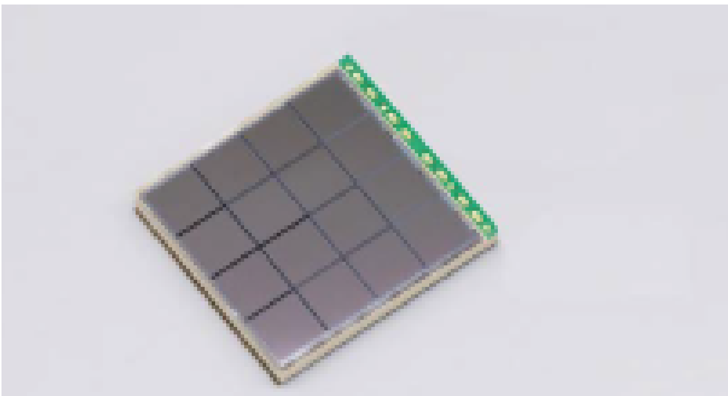


Vop

Standard light intensity

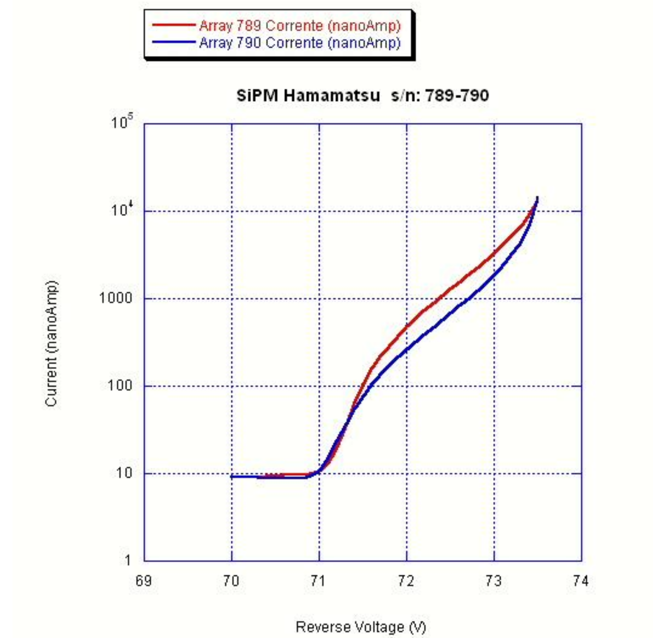
σ_t~60 ps at best, but RGB array !!

Results with Hamamatsu S11828-3344 Arrays



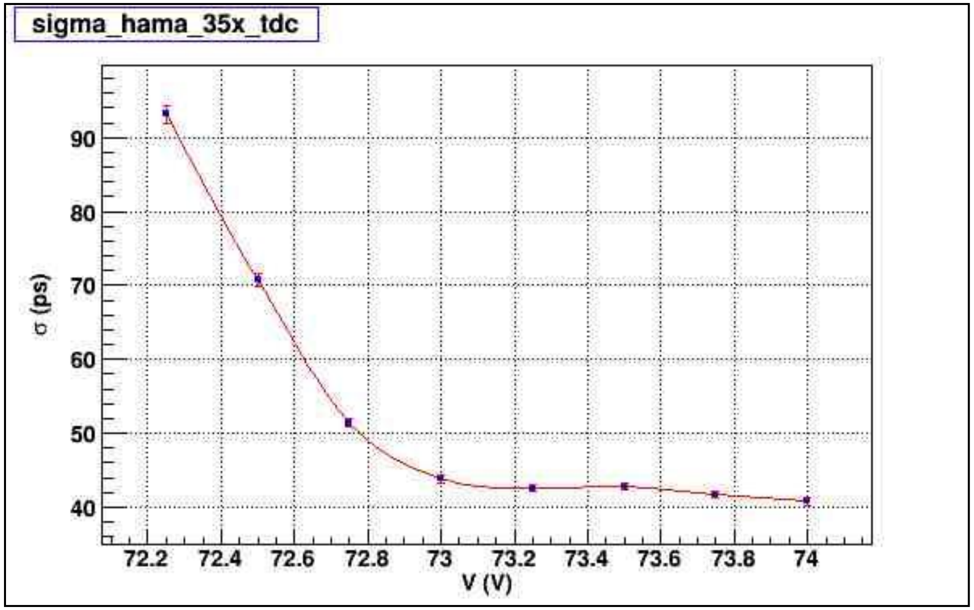
Monolithic MPPC array in SMD package
S11828-3344M

Features
- Monolithic array: 16 ch (4 × 4 array)
- Nonmagnetic package
- Effective active area: 3 × 3 mm/ch
- Pixel pitch: 50 μm
- Allows multiple devices to be arranged in a buttable format



SiPMT I-V characterisation
(our characterisation)

Results with Hamamatsu S11828 Arrays



Standard light intensity

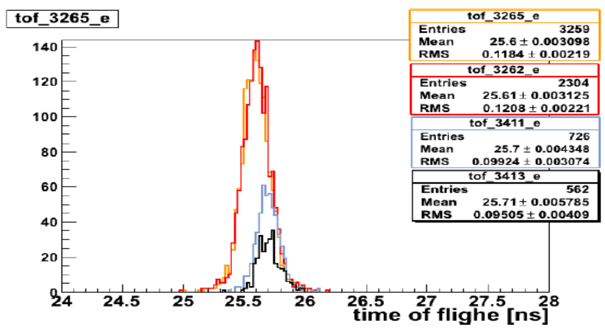
We foresee soon tests with Hamamatsu S12642 arrays, TSV package , where better results may be expected

Preliminary conclusions

- SiPMT arrays may be a good repacement for fast PMTs in scintillator time-of-flight system
- Preliminary conclusions show a “comparable” timing resolution with fast PMTs
- Clearly results must be validated by testbeam (one at BTF is foreseen)
- Some optimization may be needed: use of fast (> 1 GHz) amplifiers, NUV SiPMT arrays (instead of RGB ones) to better match scintillator emission

3. Rate effects in TOF: again …

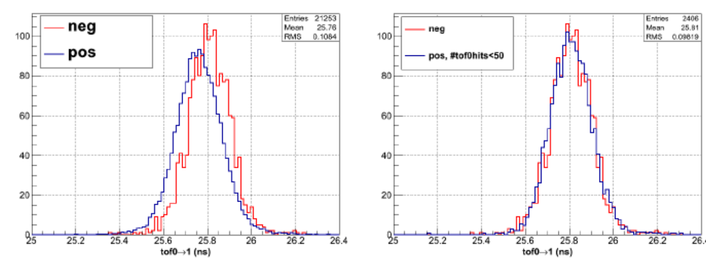
e^+e^- puzzle.



Some rate effects have been seen, but source is unclear: may be anything from PMTs to TDCs to splitters/shapers … beam …

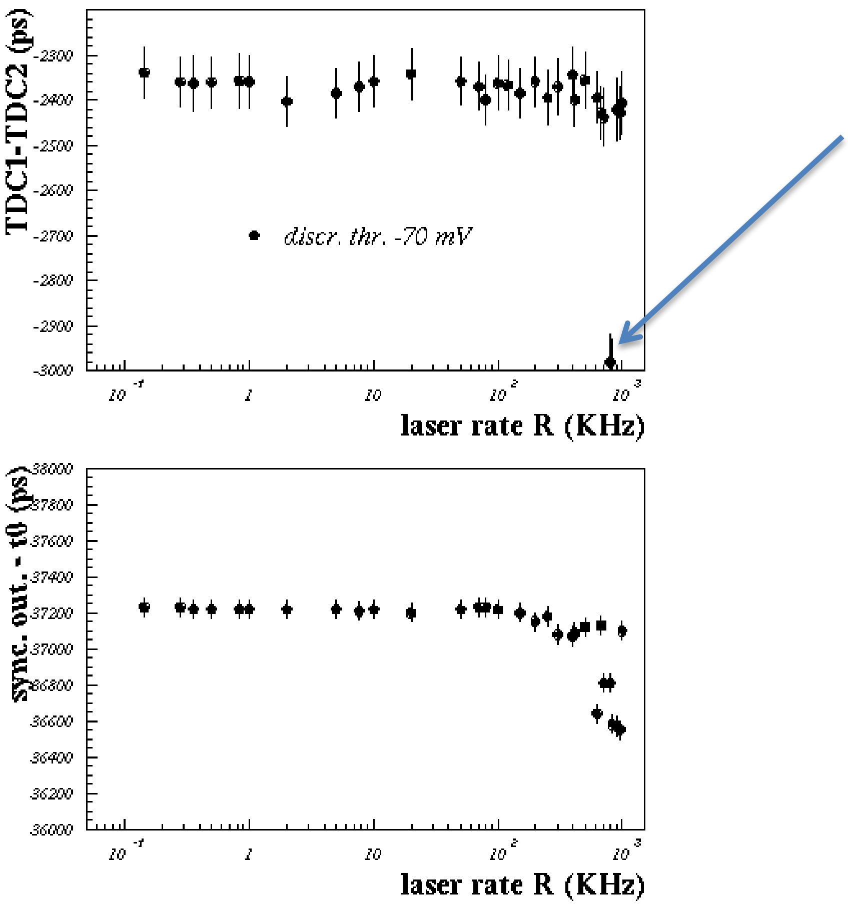
- The variation of the number of particle trigger per spill introduces difference in the measured time-of-flight ($\sim 100\ ps$) even when we use identical settings of the beamline channel.

- First looked at the time of flight for + and – data.
- Left: Obvious shift: e+ have lower tof than e-
- Right: No difference when only lower hit rate + data is selected



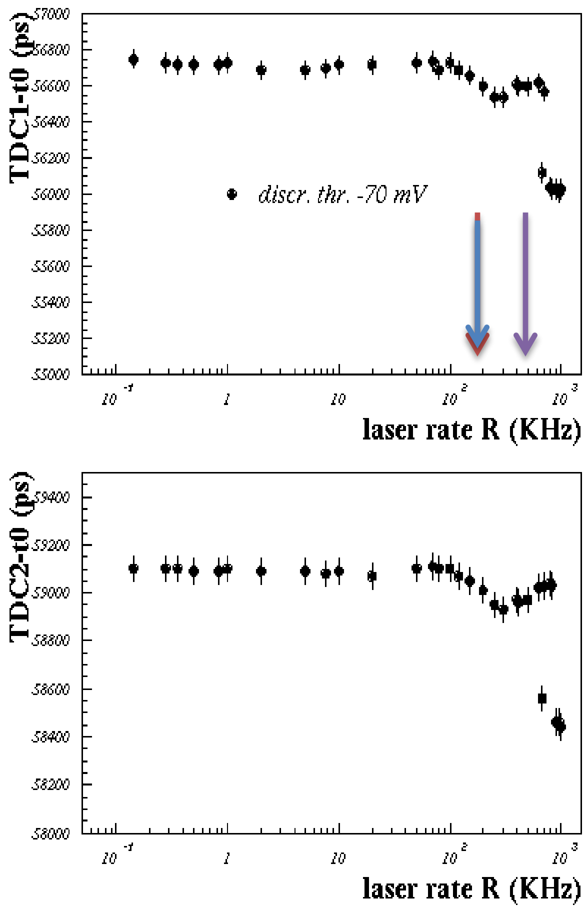
DR, A/M, 6/21/12 11

February results for TDC



This glitch prompted our attention and the need for an external t0

February results: TDC vs t0



- Some clear effects appear at very high rates > 500 KHz for single PMTs with a -70 mV thr on V895 discri. (results move of about 600 ps) with some hints at lower values (rates > 150 KHz)

New results:

- We simulated the ISIS cycle and checked how results change vs a continuos pulsing

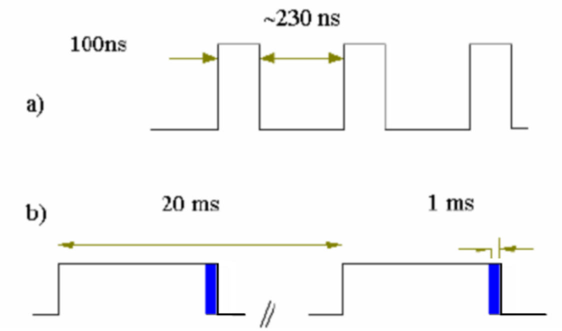
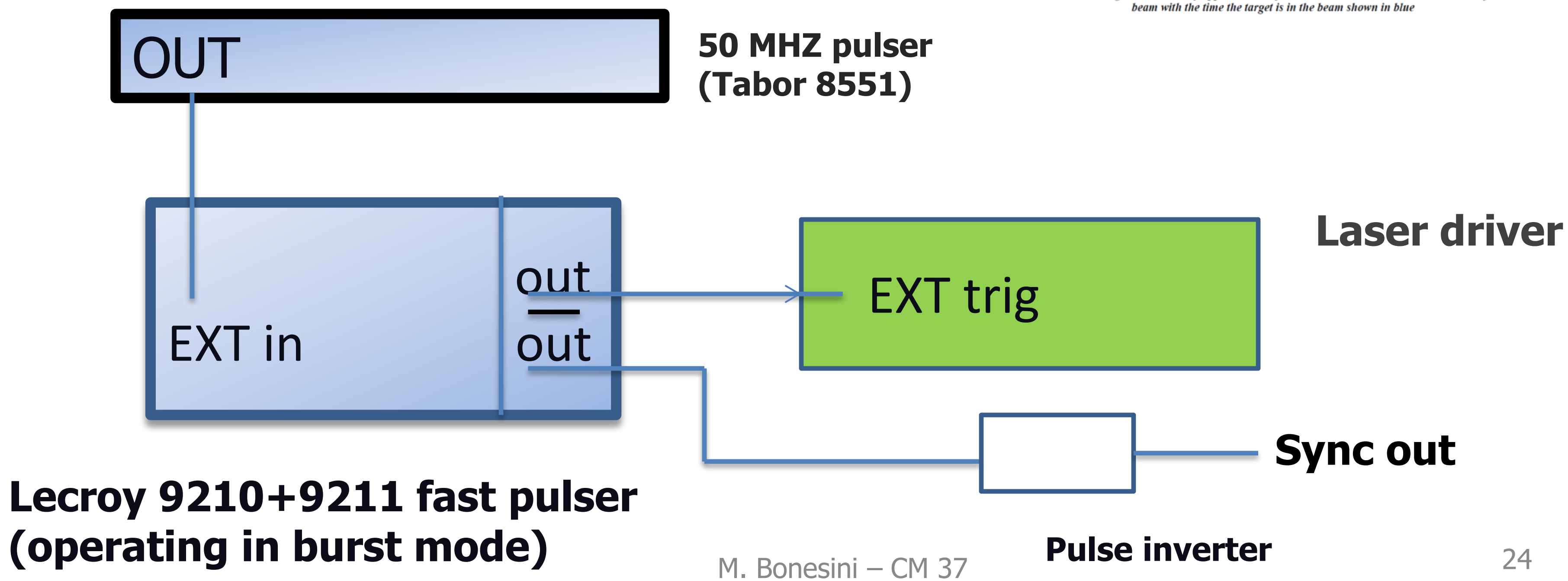
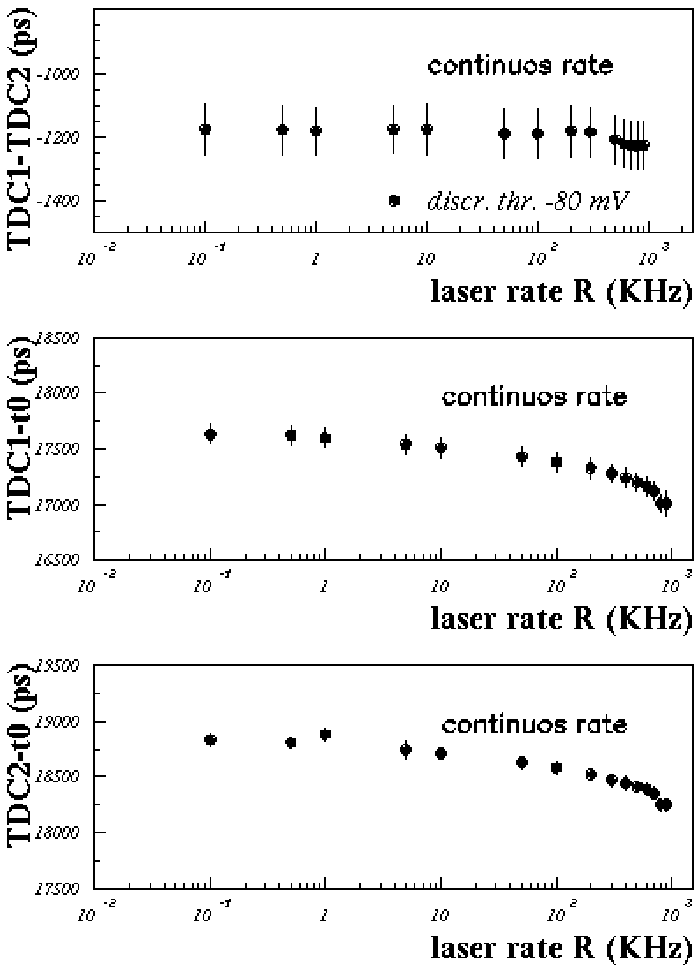


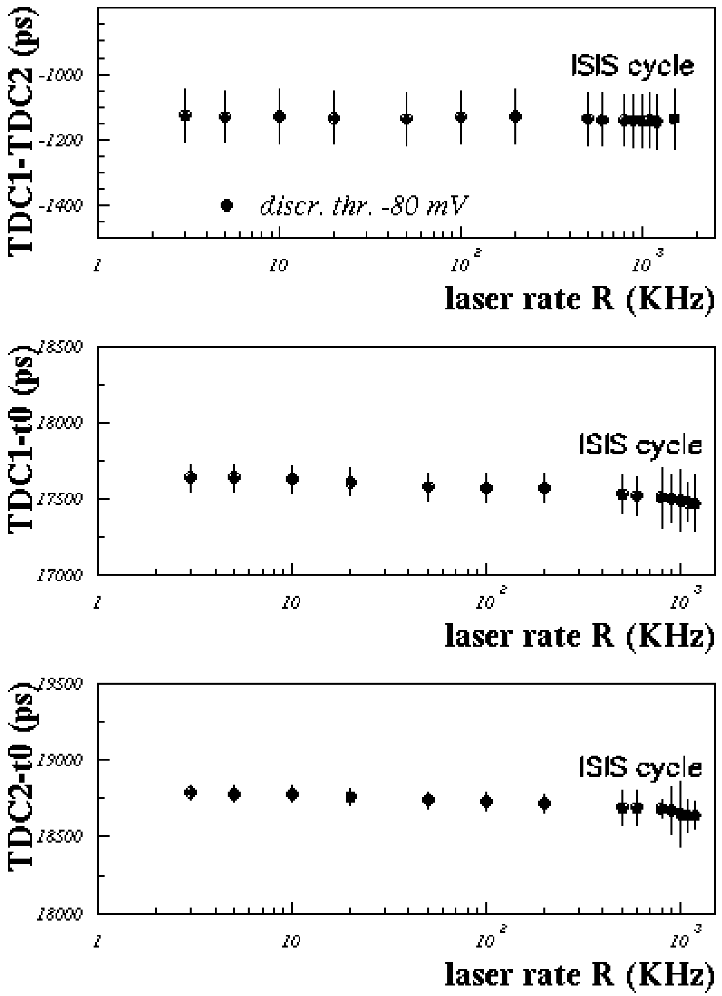
Figure7.2-1. a) the micro-structure of the ISIS synchrotron beam prior to extraction; there are two bunches rotating at diametrically opposite ends of the machine and b) the macro structure of the beam with the time the target is in the beam shown in blue



TDC vs t_0 : continuos pulsing

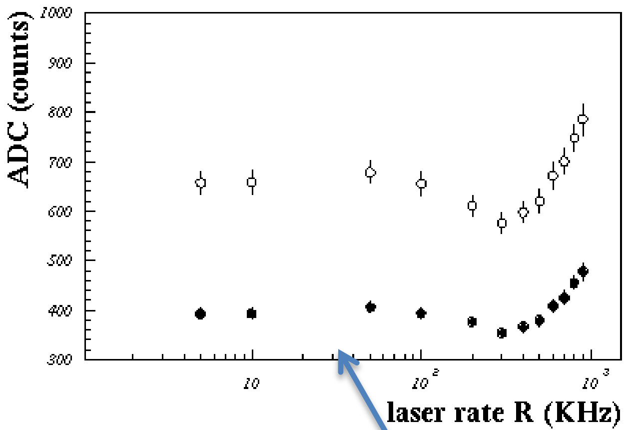


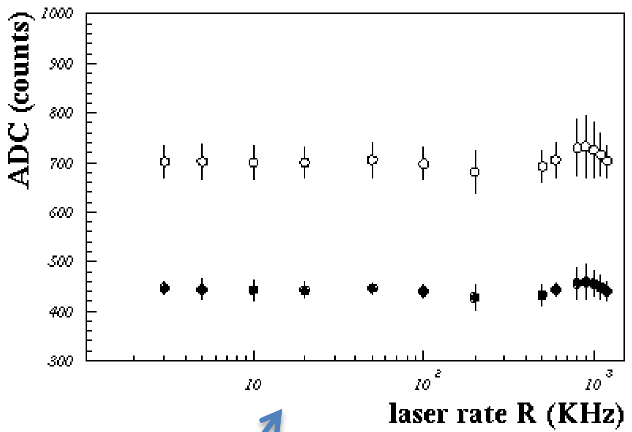
TDC vs t_0 : ISIS cycle



An ISIS-like cycling reduce the impact of rate effects

ADC vs rate

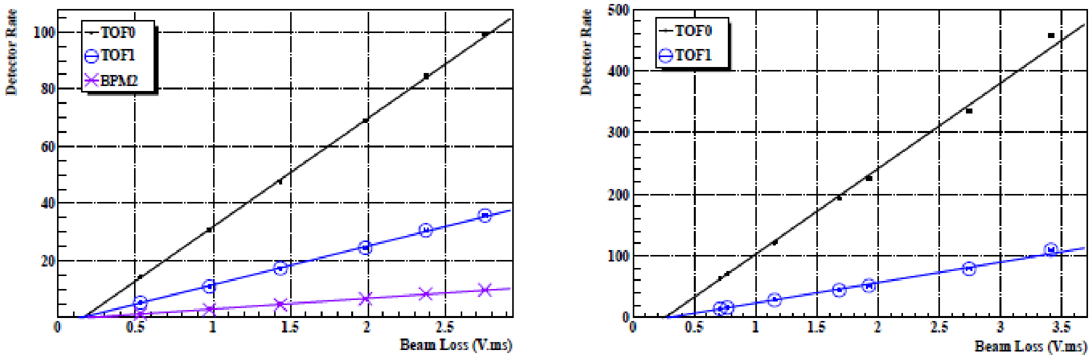




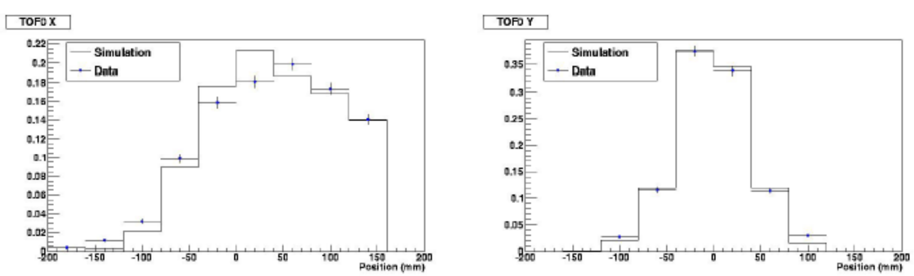
Continuos pulsing

ISIS-like pulsing

It is really a problem ?



Particle rate vs target dip



Beam profile at TOF0

From JINST paper

- Expected max rate at TOF0 for single slab for $\mu^+(\mu^-)$: **100 (30) part/spill* 0.68/4slabs~18 (6) KHz (1 V activation): with 4V activation we may go to 75 KHz**
- **A factor 5 less in TOF1**
- From previous results OK up to 150-200 KHz

Conclusions

My wise cat conclusions:

1. **Some effect seems to show up, albeit at higher rates than we experience**
2. **The ISIS cycle structure contribute to reduce their impact**
3. **The effect, if any, seems not to be connected to PMTs fatigue or VME TDCs**